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Effect of Planting Media Composition and Addition of Tempe Liquid Waste on Growth and Yield of Merang Mushrooms

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ABSTRACT

The production of merang mushrooms tends to decrease from year to year. Some factors that can cause a decrease in mushroom production are the planting media used that are less than optimal in the process of mushroom growth. Planting media from agricultural waste such as blotong and oil palm empty fruit bunch waste. Providing the appropriate planting media will be more optimal if supported by the provision of additional nutrients like tempeh liquid waste. The research was conducted in Mangaran village, Ajung District, Jember Regency, East Java from January to March 2025. The experiment was conducted factorially with the basic pattern of Completely Randomized Design (CRD) and repeated three times. Factor I is a variety of planting media composition consisting of 3 levels, namely J0 (100% straw), J1 (75% straw + 25% blotong), J2 (75% straw + 25% empty palm bunches). Factor II is the concentration of tempe liquid waste which consists of 3 levels, namely K0 (control), K1 (50% tempe liquid waste), K2 (100% tempe liquid waste). The variables observed were harvesting speed, fruit body diameter, number of fruit bodies per harvest, total number of fruit bodies, weight of fruit bodies per harvest, total weight of fruit bodies. The data obtained were analyzed using ANOVA. If there were significant differences among treatments. DMRT was conducted at the 5% level. The best results showed that the treatment combination of media composition of 75% straw + 25% oil palm empty fruit bunches and adding consentration 50% tempe liquid waste.

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INTRODUCTION

Merang mushroom is a type of mushroom that is safe for human consumption and has a high protein content so that it is in great demand by the people of Indonesia. However, based on BPS data in 2023 and 2024, it shows that the amount of merang mushroom production in Indonesia has decreased. Some of the factors that cause the decline are the planting media used that are less than optimal in the process of growing merang mushrooms (Puspitaningrum and Suparti, 2022).

Merang mushroom farmers tend to have a dependence on rice straw as a planting medium. The nutrient content in rice straw is N (0.5-0.8%), P (0.07-0.12%), K (1.2-1.7%) (Rahman et al., 2016; Patil and Singh, 2022; Zhao et al., 2024). Dependence on the use of rice straw and the content of nutrients in rice straw is one of the causes of the decline because rice straw is not always available in sufficient quantities so that there is a need for alternative planting media other than rice straw which contains nutrients to support the growth of merang mushrooms.

Merang mushroom cultivation will be more optimal if supported by the provision of appropriate planting media. Blotong is an agricultural industry waste that can be utilized for growing media for mushrooming because blotong contains 1.37% N, 1.81% P, 2.22% K, and 0.53% Mg (Syafrudin and Astuti, 2007). Empty palm bunches are suitable for use as a growing medium for merang mushrooms because they contain 1.5% N, 0.5% P, 7.3% K, and 0.9% Mg (Ginting et al., 2021; Wang et al., 2021; Nguyen et al., 2023) so that they can help meet the needs of nutrients in the process of growing merang mushrooms.

The provision of appropriate planting media will be maximized if supported by the provision of additional nutrients. One of the nutrients that can be given is the addition of tempeh liquid waste which contains 0.45% N, 0.087% P, 0.086% K (Salamah, 2009; Maulana et al., 2023; Liu et al., 2023) and complex compounds consisting of 0.42% protein, 0.13% fat, 0.11% carbohydrates, 98.87% water (Maulana et al., 2023). Giving tempeh liquid waste as merang mushroom nutrition is also one solution to reduce pollution due to industrial waste.

MATERIAL and METHOD

The research was conducted from January to March 2025 at a mushroom house (kumbung) located in Mangaran Village, Ajung District, Jember Regency, East Java Province (latitude –8.25635; longitude 113.62939). The experimental design applied was a factorial Completely Randomized Design (CRD) consisting of two factors with three replications (Gomez and Gomez, 1984). The first factor was the composition of the planting media (J), which consisted of three levels: J0 (100% rice straw), J1 (75% rice straw + 25% blotong), and J2 (75% rice straw + 25% oil palm empty fruit bunches or TKKS). The second factor was the concentration of tempeh liquid waste (K), which also had three levels: K0 (control or 0%), K1 (50% consisting of 500 mL tempeh liquid waste plus 500 mL water per liter of solution), and K2 (100% consisting of 1000 mL tempeh liquid waste per liter of solution). A total of 3 × 3 = 9 treatment combinations were prepared, and each treatment combination was replicated three times, resulting in 27 experimental units.

The tools used are digital vernier, digital scales, thermometer, sprayer, hygrometer, pasteurization drum, timba, knife/machete, stationery, mobile phone, and other supporting tools. Materials used were merang mushroom seeds, water, agricultural lime, bran, rice straw, blotong, oil palm empty fruit bunches, and tempeh liquid waste. The procedure for conducting research is the preparation of planting media, composting media, pasteurization, spreading merang mushroom seeds, spraying tempe liquid waste, maintenance stage, and harvesting. The observation parameters are harvesting speed, fruit body diameter, number of fruit bodies per harvest, total number of fruit bodies, weight of fruit bodies per harvest, total weight of fruit bodies.

Harvesting speed (days after inoculation, DAI) was calculated as the number of days from inoculation to the first harvest:

$$DAI = t_{first\ harvest} - t_{inoculation} \tag{1}$$

(Gomez and Gomez, 1984; Steel and Torrie, 1997)

Fruit-body diameter (mm), each fruit body was measured in two perpendicular directions and averaged. The mean diameter for each harvest was calculated as:

$$\mathrm{d}_i = \frac{d_{i,\max} + d_{i,min}}{2},\ d_h = \frac{1}{n_h}\sum_{i=1}^{n_h} \mathrm{d}_i \tag{2}$$

and the overall mean across all harvests:

$$d = \frac{1}{H}\sum_{h=1}^{H} \mathrm{d}_h \tag{3}$$

(Gomez and Gomez, 1984; Chang and Miles, 2004)

Number of fruit bodies per harvest (pieces), the total number of fruit bodies counted in each harvest:

$$\mathrm{N}_h = \sum_{i=1}^{nh} 1 = n_h \tag{4}$$

(Steel and Torrie, 1997; Chang and Miles, 2004)

Total number of fruit bodies (pieces), the cumulative number of fruit bodies from all harvests:

$$N_{total} = \sum_{h=1}^{H} N_h \tag{5}$$

(Gomez and Gomez, 1984; Chang and Miles, 2004).

Fruit-body weight per harvest (g), the total weight of all fruit bodies in harvest h:

$$\mathrm{W}_h = \sum_{i=1}^{n_h} \mathrm{Wh}_{,i} \tag{6}$$

(Chang and Miles, 2004)

Total weight of fruit bodies (g), the cumulative weight of fruit bodies from all harvests:

$$\mathrm{W}_{total} = \sum_{h=1}^{H} \mathrm{W}_h \tag{7}$$

(Gomez and Gomez, 1984; Chang and Miles, 2004).

Statistical Analysis

Observational data obtained were analysed using analysis of variance, if there were significant differences between treatments then further tests were carried out using Duncan's multiple range test at the 5% level.

RESULTS and DISCUSSION

Based on the results of the analysis of variance in Table 1, it shows that the interaction between the composition of planting media and the addition of tempe liquid waste has a significant effect on the observation variables of fruit body diameter, total number of fruit bodies, and total weight of fruit bodies. While the main factor of the effect of the composition of planting media affects the observation variable of the number of fruiting bodies per harvest, the total number of fruiting bodies, the weight of fruiting bodies per harvest, and the total weight of fruiting bodies. While the main effect of the factor of adding tempeh liquid waste affects the total number of fruit bodies and the total weight of fruit bodies.

Table 1. Summary of the results of analysis of variance on all observation variables

No.	Observation Variables	F-Count Value		
		Media Composition (J)	**Liquid tempe waste (K)**	**Interaction (J x K)**
1.	Harvest speed (hst)	0,24 ns	0,76 ns	0,24 ns
2.	Fruit body diameter (mm)	0,54 ns	2,33 ns	3,46 *
3.	Number of fruit bodies per harvest	16,68 **	2,68 ns	1,25 ns
4.	Total fruit bodies	49,16 **	10,54 **	3,88 *
5.	Fruit body weight per harvest	13,54 **	0,67 ns	0,18 ns
6.	Total fruit body weight (g)	77,47 **	10,93 **	3,41 *

** Significantly different, * Significantly different ns Not significantly different

Effect of Interaction of Planting Media Composition and Addition of Tempe Liquid Waste on Growth and Yield of Merang Mushrooms

As shown in Table 2, the interaction between planting media composition and tempeh liquid waste concentration significantly affected the fruiting body diameter.

Table 2. The results of Duncan's multiple range test (α = 5%) on the interaction effect of the treatment of planting media composition and concentration of tempeh liquid waste on the observation variable of fruiting body diameter

Media Composition	Tempe Liquid Waste Concentration		
	K_0 (Control)	**K_1 (50% Tempe Liquid Waste)**	**K_2 (100 % Tempe Liquid Waste)**
J_0 (100% Straw)	26,57 (a) (AB)	28,83 (a) (AB)	29,00 (a) (A)
J_1 (75% Straw + 25% Blotong)	28,87 (a) (A)	27,20 (a) (B)	29,00 (a) (A)
J_2 (75% Straw + 25% TKKS)	26,03 (b) (B)	30,07 (a) (A)	26,73 (b) (A)

Description: Numbers followed by the same lowercase letters (horizontal) show no significant difference in the simple effect of the concentration of tempeh liquid waste at the same level of media composition. Numbers followed by the same capital letter (vertical) show no significant difference in the simple effect of planting media composition at the same level of concentration of tempeh liquid waste.

The interaction effect on the total number of fruiting bodies is detailed in Table 3.

Table 3. The results of Duncan's multiple range test (α = 5%) on the interaction effect of the treatment of planting media composition and concentration of tempeh liquid waste on the observation variable of total number of fruiting bodies.

Media Composition	Tempe Liquid Waste Concentration		
	K_0 (Control)	**K_1 (50% Tempe Liquid Waste)**	**K_2 (100 % Tempe Liquid Waste)**
J_0 (100% Straw)	42,00 (a) (B)	48,00 (a) (C)	46,00 (a) (C)
J_1 (75% Straw + 25% Blotong)	66,00 (a) (A)	75,00 (a) (B)	64,33 (a) (B)
J_2 (75% Straw + 25% TKKS)	70,00 (b) (A)	111,67 (a) (A)	81,67 (b) (A)

Description: Numbers followed by the same lowercase letters (horizontal) show no significant difference in the simple effect of the concentration of tempeh liquid waste at the same level of media composition. Numbers followed by the same capital letter (vertical) show no significant difference in the simple effect of planting media composition at the same level of concentration of tempeh liquid waste.

The results for the total weight of fruiting bodies are presented in Table 4. Based on the analysis of variance table, the interaction between media composition and the addition of tempeh liquid waste had a significant effect on the observation variables of fruiting body diameter, total number of fruiting bodies, and total weight of fruiting bodies. The highest results for fruiting body diameter were obtained from the treatment combination of 75% straw + 25% TKKS and the addition of 50% concentration of tempeh liquid waste (J_2K_1) with a fruiting body diameter of 30.07 mm, the highest total number of fruiting bodies was obtained from the treatment combination of 75% straw + 25% TKKS and the addition of 50% concentration of tempeh liquid waste (J_2K_1) with an average of 111.67 pieces, and the highest total weight of fruiting bodies was obtained from the treatment combination of 75% straw + 25% TKKS and the addition of 50% concentration of tempeh liquid waste (J_2K_1) with an average of 1993.97 g.

Table 4. The results of Duncan's multiple range test (α = 5%) on the interaction effect of the treatment of planting media composition and concentration of tempeh liquid waste on the observation variable of total weight of fruiting bodies

Media Composition	Tempe Liquid Waste Concentration		
	K_0 (Control)	**K_1 (50% Tempe Liquid Waste)**	**K_2 (100 % Tempe Liquid Waste)**
J_0 (100% Straw)	977,10 (a) (C)	1048,60 (a) (C)	1025,37 (a) (C)
J_1 (75% Straw + 25% Blotong	1313,57 (a) (B)	1522,00 (a) (B)	1425,07 (a) (B)
J_2 (75% Straw + 25% TKKS)	1543,87 (b) (A)	1993,97 (a) (A)	1544,10 (b) (A)

Description: Numbers followed by the same lowercase letters (horizontal) show no significant difference in the simple effect of the concentration of tempeh liquid waste at the same level of media composition. Numbers followed by the same capital letter (vertical) show no significant difference in the simple effect of planting media composition at the same level of concentration of tempeh liquid waste.

Recommendations for merang mushroom cultivation are to use the treatment combination of J_2K_1 and the addition of 50% concentration of tempeh liquid waste (J_2K_1) with an average of 1993.97g. The recommendation for merang mushroom cultivation is to use the J_2K_1 treatment combination to get maximum results. According to Rahman et al. (2016) the content of straw is N (0.5-0.8%), P (0.07-0.12%), K (1.2-1.7%), cellulose (32-45%), hemicellulose (20-25%), lignin (10-15%). The content of oil palm empty fruit bunches is 1.5% N, 0.5% P, 7.3% K, and 0.9% Mg (Ginting et al., 2021). Straw is a planting medium that is rich in cellulose and to provide a carbon source for the growth of merang mushrooms, but has a fairly low nitrogen content, so it is necessary to combine planting media to meet the needs of merang mushrooms.

The composition of 75% straw + 25% oil palm empty fruit bunches to provide an optimal ratio because it has a perfect balance such as being able to support in maintaining aeration in the growing medium. The addition of the right concentration of 50% tempeh liquid waste is able to increase nutrient levels in the growing medium, accelerate mycelium growth, and increase the yield of merang mushroom because this proportion is able to ensure the availability of appropriate nutrients without toxic effects. So that the treatment combination of 75% straw + 25% TKKS and the addition of 50% concentration of tempeh liquid waste gives the best results because the treatment combination can support the availability of proper nutrients in the process of mushroom growth. This is supported by research conducted by Apriyandi et al

(2018) on merang mushrooms using the composition of straw and sago pulp planting media showing that there is a significant effect of the interaction between straw and sago pulp planting media with the addition of tempe liquid waste as a support for providing nutrients to fruiting body length, total weight of merang mushrooms per harvest, and the number of merang mushrooms per harvest (Patil and Singh, 2022; Zhao et al., 2024).

The Effect of Planting Media Composition on the Growth and Yield of Straw Mushrooms

The average main effect of media composition on the observation variable of harvest speed is presented in Figure 1. The results of Duncan's multiple range test at the 5% level, showing the main influence of the treatment factor of planting media composition on the variable number of fruit bodies per harvest, are displayed in Figure 2, Figure 3 illustrates Duncan's multiple range test results at the 5% level, indicating the main influence of the treatment factor of planting media composition on the variable of the weight of the fruit body at each harvest.

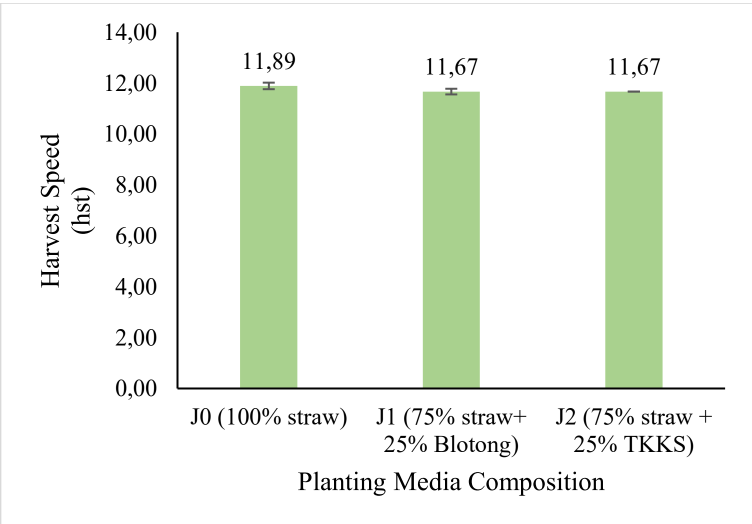

Figure 1. The average main effect of media composition on the observation variable of harvest speed

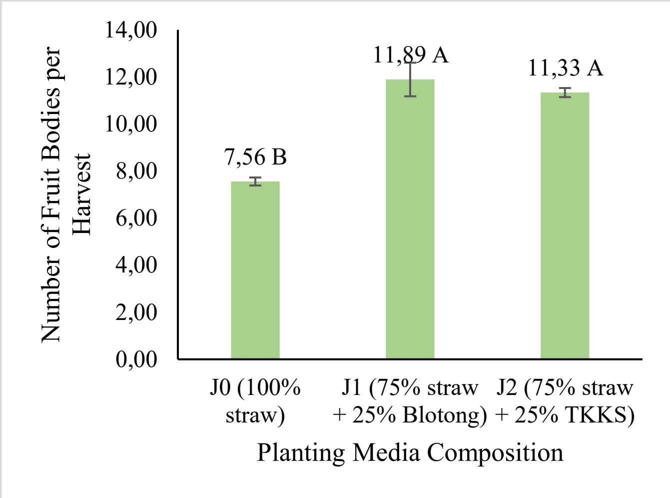

Figure 2. The results of Duncan's multiple range test at 5% level showed the main influence of the treatment factor of the composition of the planting media on the variable number of fruit bodies per harvest

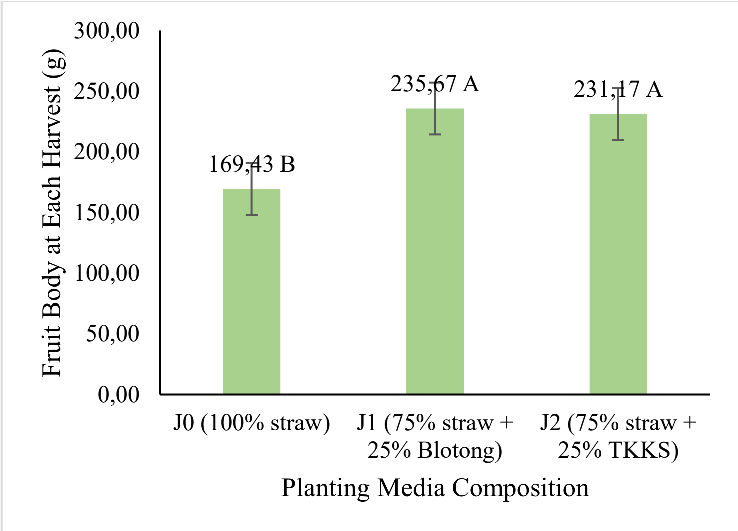

Figure 3. Duncan's multiple range test results at 5% level of the main influence of the treatment factor of the composition of the planting media on the variable of the weight of the fruit body at each harvest

Based on the results of the Duncan multiple range test at the 5% level, the main effect of the composition of planting media shows that the best treatment is shown by the composition of planting media 75% straw + 25% blotong (J_1) which is not significantly different from the treatment of planting media composition 75% straw + 25% empty palm bunches. This is in line with research by Riyati and Sumarsih (2002) which states that the use of blotong media in white oyster mushroom cultivation affects the wet weight and dry weight of white oyster mushrooms. Blotong contains 1.37% N, 1.81% P, 2.22% K, and 0.53% Mg (Syafrudin and Astuti, 2007) and straw is N (0.5-0.8%), P (0.07-0.12%), K (1.2-1.7%) (Rahman et al., 2016). The composition of straw and blotong planting media can increase the activity of microorganisms to accelerate the decomposition of lignocellulose to accelerate the availability of nutrients for merang mushrooms. Giving blotong in certain compositions can provide nutrients for mushrooms but excessive use will cause a decrease in the total content of lignocellulose in mushroom growth because mushrooms require nutrients available in the growing media used (Riyati and Sumarsih, 2002).

Based on research by Sari et al. (2023), the cultivation of merang mushrooms using oil palm empty bunches planting media affects the height of mushrooms, mushroom diameter, biomass, and production of merang mushrooms. Oil palm empty bunches contain 1.5% N, 0.5% P, 7.3% K, and 0.9% Mg (Ginting et al., 2021) and straw, namely N (0.5-0.8%), P (0.07-0.12%), K (1.2-1.7%) (Rahman et al., 2016). The treatment of the composition of straw planting media and empty palm bunches as a growing medium for merang mushrooms can create a planting medium that supports air circulation and stable humidity. This shows that the right composition of planting media will provide optimal nutrition for mushroom growth because it not only increases the availability of nutrients but also improves the physical and chemical properties of planting media.

The Effect of Adding Tempe Liquid Waste on the Growth and Yield of Straw Mushrooms

The average main effect of media composition on the observation variable of harvest speed is shown in Figure 4, Figure 5 presents the average main effect of media composition on the observation variable of the number of fruit bodies per harvest. The average main effect of media composition on the observation variable of fruit body weight per harvest is illustrated in Figure 6.

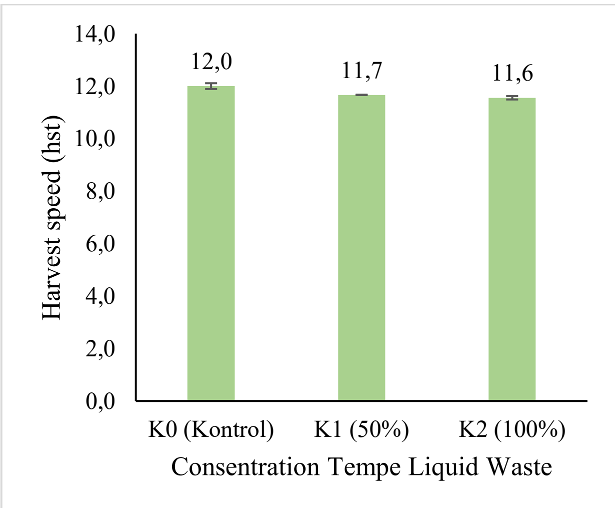

Figure 4. The average main effect of media composition on the observation variable of harvest speed

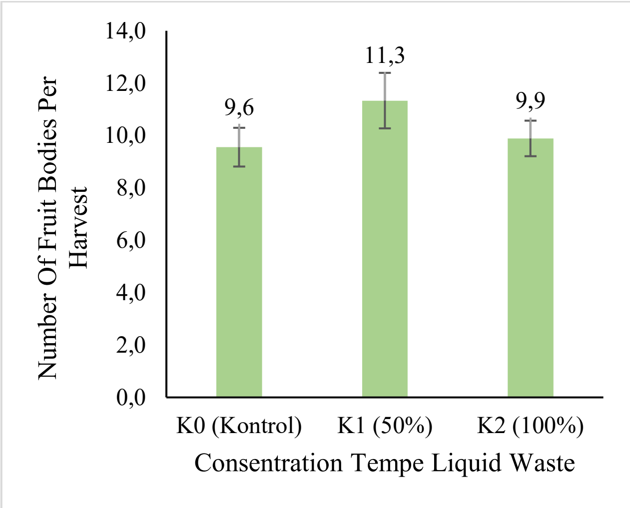

Figure 5. The average main effect of media composition on the observation variable of the number of fruit bodies per harvest

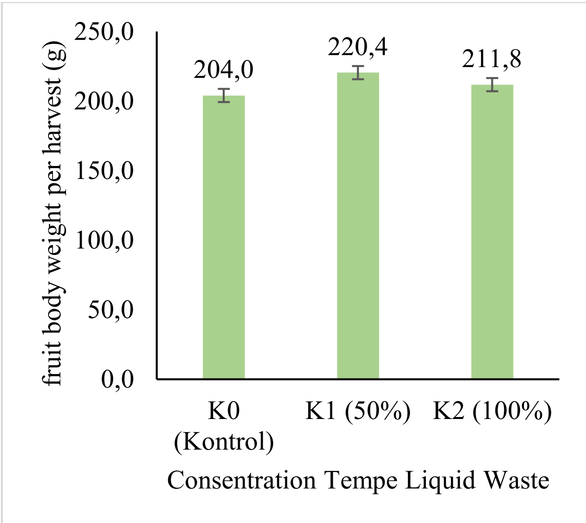

Figure 6. The average main effect of media composition on the observation variable of fruit body weight per harvest

Based on the results of the Duncan multiple range test at the 5% level, the best concentration of tempeh liquid waste is at a concentration of 50% tempeh liquid waste (K_1). This is in accordance with research conducted by Maulana et al. (2023) which states that the addition of a 50% concentration of tempeh liquid waste influece the weight of the fruiting bodies of merang mushrooms. Tempe liquid waste can support growth and yield because it contains 0.45% N, 0.087% P, 0.086% K (Salamah, 2009) and complex compounds consisting of 0.42% protein, 0.13% fat, 0.11% carbohydrates, 98.87% water (Maulana et al., 2023). The content of organic matter such as carbohydrates is able to support the growth of mycelium of merang mushroom because it is a source of energy for mycelium to grow and the water content is able to provide optimal moisture for fruiting body formation and absorption of dissolved nutrients so that it can produce maximum fruit compared to not given the addition of tempeh liquid waste (Liu et al., 2023).

CONCLUSION

This study shows that combining 75% rice straw + 25% oil-palm empty fruit bunches (EFB/TKKS) with a 50% tempeh liquid-waste spray (treatment J2K1) consistently delivered the best performance, highest fruit-body diameter, total number of fruit bodies, and total yield (1993.97 g per experimental unit) compared with other treatments. For farmers, these results are practical and beneficial: lower input risk and cost by reducing reliance on rice straw whose availability can be erratic through partial substitution with locally abundant EFB, valorization of agricultural/food-industry wastes (EFB and tempeh liquid waste) into productive growing inputs, contributing to waste-to-resource strategies and potential environmental co-benefits, and simple field operations (substrate mixing and low-tech spraying) that are compatible with smallholder practices. Taken together, adopting the J2K1 formula offers a feasible path to higher and more stable yields while lowering dependency on single-source substrates, aligning agronomic performance with on-farm economics and circular bioresource use.

Conflict of Interest

The authors have declared that there are no competing interests.

Authors Contribution

The authors contribute equally to the research

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